淡江大學九十學年度碩士班招生考試試題

系別：化學工程學系　　科目：輸送現象與單元操作

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1. In Fig. 1 a tank of water is immersed in a larger tank of gasoline and the water is flowing through a hole in the bottom. What is the velocity of the flow? ($\rho_{gasoline} = 0.72\ g/cm^3$) (20%)

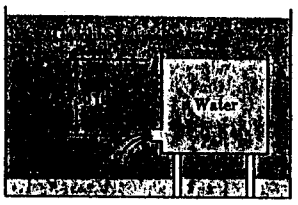

Fig. 1

2. The system in Fig. 2 consists of a water reservoir with a layer of compressed air above the water and a large pipe and nozzle. The pressure of air is 50 *psig*, and the effects of friction can be neglected. What is the velocity of the water flowing out through the nozzle? (20%)

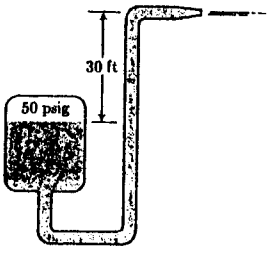

Fig. 2

3. A counterflow, concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water the inner tube is 0.2 *kg/sec*, while the flow rate of oil through the outer annulus is 0.1 *kg/sec*. The oil and water enter at temperatures of 100 and 30°*C*, respectively. What is the transfer area of the tube if the outlet temperature of the oil is to be 60°*C*? (The overall convection coefficient is $U = 37.8\ W/m^2 \cdot K$; the specific heat at constant pressure of oil and water are $c_{p,oil} = 2131\ J/kg \cdot K$ and $c_{p,water} = 4178\ J/kg \cdot K$, respectively;.) (20%)

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4. A constant-density newtonian fluid is flowing as a thin film down a vertical wall in laminar flow. Find the velocity distribution and the volumetric flow rate per unit width of wall by using the Navier-Stokes equations (z component) on the assumptions that there is no flow in the x or y directions, that the z component of the velocity is zero at the solid wall, there is a shear stress at the gas-liquid interface in the upward direction as seen by the liquid with magnitude A (where A has dimensions of force divided by area), and that the flow is steady-state. (We are blowing air upward next to the fluid film, wave may appear on the fluid surface in this situation; ignore that possibility for the problem.) (20%)

5. A plane wall that is insulated on one side (x=0) is initially at a uniform temperature T_i, when its exposed surface at x=L is suddenly raised to a temperature T_s.

(a) Verify that the following equation correctly characterizes the subsequent variation of the wall temperature, $T(x,t)$, with position and time:

$$\frac{T(x,t)-T_s}{T_i-T_s}=C_1\exp\left(-\frac{\pi^2}{4}\frac{\alpha t}{L^2}\right)\cos\left(\frac{\pi}{2}\frac{x}{L}\right)$$

where C_1 is a constant and α is the thermal diffusivity. (5%)

(b) Obtain expressions for the heat flux at x=0 and x=L. (5%)

(c) Sketch the temperature distribution $T(x)$ at t=0, at $t\to\infty$, and at an intermediate time. Sketch the variation with time of the heat flux at x=L, $q''_L(t)$. (5%)

(d) What effect does α have on the thermal response of the material to a change in surface temperature? (5%)